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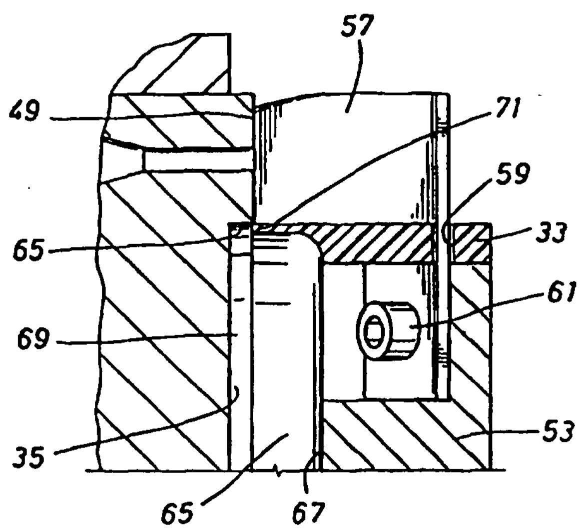
(54) Title: UNDERWATER PELLETIZER

(57) Abstract

An improved underwater pelletizer adapted to prevent extruded material from agglomerating in a pelletizing assembly, which pelletizer comprising a cutting assembly having (1) a shroud for preventing pellets from being trapped between the die face and the cutting assembly; and (2) novel knives contoured to conform in their angular positions to the curvature of the shroud.



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DESCRIPTION

UNDERWATER PELLETIZER

Technical Field

This invention relates t underwater thermoplastic pelletizers and, in particular, to underwater pelletizers having improved means for cutting thermoplastic strands into pellets. This invention also relates to an improved method for preventing extruded material from agglomerating in an pelletizing assembly. This invention further relates to an improved process for producing pellets of thermoplastics, particularly ultra low melt viscosity polyolefins.

Background Art

The pelletization of extrudable materials is of considerable importance for many applications. Pellets, unlike ingots or bars, readily flow in measuring and dispensing apparatus and the size of pellet charges can be readily controlled to small tolerances. Moreover, unlike powders, they do not form dust and are not ingested by persons working with them. Thus, they provide a highly convenient form for the packaging, storage and use of many thermoplastic polymers, food products, etc.

Underwater pelletizers are known which employ a rotating disc cutter to cut or sever stranded polymer as it exits from the die plate of an extruder. The cutting is accomplished in a chamber full of circulating water which functions to cool the strand and also to carry away the cut pellets. The prior art disc cutters are of two types: (1) knives which extend radially from a central hub or (2) multiple blades which are attached to spoked hubs.

Attempts to use the prior art disc cutters to pelletize extrudable materials such as fluidic materials which require a relatively long time to solidify have resulted in agglomeration of extruded materials in the pelletizers. The extruded materials often are trapped in the area between the cutting hub and the die face and agglomerates into "trashouts". The extruded materials also agglomerate and wrap around the extended knife blades.

It is known that ultra l w melt visc sity polymers are useful f r the pr duction f a variety of products such as adhesives, sealants, coatings, non-wov n fabrics by melt blown fiber processes, injection-molded c mponents made at a high rate, etc. An ultra low melt viscosity polymer has a melt viscosity of about 300,000 centipoise (hereinafter "cps") or lower. The melt viscosity of an ultra low melt viscosity polymer can be as low as 500 cps or smaller.

Pelletization of thermoplastic polymers, especially high melt flow thermoplastic polyolefins, have been particularly difficult using prior art underwater pelletizers. This problem is especially eminent in the production of ultra high melt flow and ultra low viscosity adhesive grade butene-1-ethylene copolymers which contains from about 0.1 to 8 wt% of ethylene which are cracked by a free radical generator. The problem appears to relate to the slow crystallization rate of these polymers which exhibit extreme tackiness in pelletizing. It is known that as the pellets leave the cutting blades, they are very tacky and collide with other pellets to form agglomerates. With a longer residence time, the pellets change to an opaque color, as they complete their crystallization, become dense and lose their tackiness. Excessive turbulence around the trailing edges of the knives also contribute to the agglomeration problem. These agglomerates wrap around the cutting blades and create smears and chunks, plugging the pelletizer chamber, the spin dryer and the area between the die and hub. The extrusion line has to be shut down in order to clean the plugged section resulting in undesirable production interruptions. The agglomerations also result in an excess amount of non-uniform or malformed pellets which may be described by terms such as tailed pellets, long-string pellets, pellet marriages, elbows, dog bones, and pellet trash which are undesirable.

Referring to FIG. 1 and FIG. 2, US-A-4,621,996, issued November 11, 1986, and assigned to Gala Industries, proposes a conventional underwater plastic pelletizing

machine which includes a number of flat cutting blades 21 mounted on a spoked hub 23 n a driven shaft 25 so that the extruded strand of plastic will be cut into a plurality of pellets. The cutting blades 21 proposed pr ject outward, according to the drawing, from the spoked hub 23. There is a gap 29 between the spoked hub and the die face. This cutter design would not process a high melt flow, adhesive grade polymer properly because polymer smears in long strands and wraps around the cutting blades 21 and sharp edges on the hub 23. This is particularly true when the polymer processed has a relatively low viscosity, high tackiness and long crystallization time which make underwater pelletizing very difficult. It is known that excessive turbulence around the trailing edges of the knives also contributed to the wrapping problem.

It is also known that the extruded polymer pellets are entrapped in the gap 29 between the die face 31 and the hub creating smears and chunks, and thus plugging up the pelletizer. It is not practical to use this prior art pelletizer to pelletize adhesive grade ultra high melt flow polybutene-1-ethylene described above because of the frequency of shut downs required for cleaning up the plugged section.

As used herein, a high melt viscosity polymer is a polymer having a melt viscosity 1,000,000 cps or more; and an ultra low melt viscosity polymer is a polymer having a melt viscosity of about 300,000 cps or lower. A polymer with a melt viscosity of about 300,000 cps will have a melt index of approximately 100 dg/min, and is generally regarded as an ultra high melt flow rate polymer with an ultra high melt index. As used herein, the melt viscosity is measured by Brookfield Viscometer using ASTM D2556 at 350 degrees Fahrenheit (°F), unless otherwise specified e.g. as measured at 275°F. As used herein, the melt flow rates or melt indices are measured by ASTM 1238 condition E at 190°C and 2.16 kg wt.

Brief Description of the Drawings

FIG. 1 is a vertical sectional view of the prior art underwater p lletiz r, disclosed in US-A-4,621,996, with flat cutting blades m unted on a sp ked hub secured on a driven shaft. There is a gap between the spoked hub and the die face.

FIG. 2 is a front view on the line 2--2 of FIG. 1 of the prior art underwater pelletizer disclosed in US-A-4,621,996.

FIG. 3 is a vertical sectional view of a pelletizer of the second preferred embodiment of the present invention having a shroud of an annular ring fitted to the outer periphery of the cutting hub. The outer periphery of the shroud is held to a close clearance to the inner diameter of the raised die ring to effect a barrier against pellet migration. The cutting blades are contoured to conform to the outer periphery of the shroud eliminating any gaps between the cutting blades and the outer periphery of the cutting hub.

FIG. 4 is a partially sectional view of the arrangement of the shroud, cutting hub, die ring and cutting blades according to a second preferred embodiment of the present invention.

FIG. 5 is a fragmental section on the line 5--5 of FIG. 4, on an enlarged scale, showing the interface of the shroud, cutting hub, die ring and cutting blades when a cutting blade is relatively new. The edge of the shroud is not in contact with the bottom surface of the recess of the die face.

FIG. 6 is a fragmental section on the line 5--5 of FIG. 4, on an enlarged scale, when a cutting blade has been worn and the cutting has been advanced. The edge of the shroud is wearing against the bottom of the recess of the die face.

FIG. 7 is a front view on the line 7--7 of FIG. 4, viewing from the side furthest from the die according to the first specific embodiment of the present invention.

FIG. 8 is a rear view f the cutting hub of FIG. 7 viewing from the sid cl s st t the die.

FIG. 9 is a fragmental s ction on the line 9--9 of FIG. 8 illustrating the mounting of the cutting blad to the cutting hub of FIG. 8.

FIG. 10 is a fragmental side-view on the line 10--10 of FIG. 8 of the cutting assembly of FIG. 8 showing the shroud extending slightly beyond the cutting plane of the cutting blade, and the bottom portion of the annular ring being thinner than the upper portion.

FIG. 11 is a fragmental sectional view, of the cutting assembly according to a second specific embodiment of the present invention having a cup shaped shroud which does not change position as the cutting blades are worn and advanced. Cutting blades are bolted to the outer surface of the cutting hub and a backcover is bolted to the outer side of the cutting hub to prevent pellet agglomeration at the outer side of the cutting hub. The backcover has a skirt to close the gap in the slot for insertion of the blade, said gap is formed from hub and blade advancement as cutting blades are worn.

FIG. 12 is a fragmental sectional view of the cutting assembly of FIG. 11 showing the cutting hub advanced toward the die face as the cutting blades are worn and advanced while the shroud remains at the same position.

FIG. 13 is a vertical sectional view of a pelletizer of the third preferred embodiment of the present invention having a cup-shaped shroud fixedly mounted to the recess in the center of a die ring. The shroud is held to a minimum clearance to the inner surface of the hub to effect a barrier against pellet migration. The cutting blades are contoured to conform to the outer periphery of the shroud and hub thereby eliminating any gaps between the cutting blades and the outer periphery of the cutting hub and the shroud.

FIG. 14 is a front view of FIG. 13, viewing from the side furthest from the die, illustrating the arrangement

of the shaft, cutting hub, die ring and cutting blades acc rding to a third pr ferred embodiment of the present invention.

Detailed Description of the Preferred Embodiments

The present invention in its broadest scope relates to a pelletizing assembly for pelletizing an extruded material, said pelletizing assembly comprising:

A pelletizing assembly for pelletizing an extruded material, said pelletizing assembly comprising:

an extrusion die plate comprising:

a die face at a downstream side of the die plate;

a die ring formed on the downstream side of the die face having a wear surface projecting outwardly from the die surface to form a recess in the center of the die ring, and said recess having a bottom surface facing the inner surface of hub; and

a channel means extending from upstream side of the die plate to the die face adapted to deliver the extruded material from the upstream side of the die plate to the die face for extrusion, and said channel means forming an orifice in the die face for extruded material to exit the die plate;

a cutting assembly mounted for rotation adjacent the die face, said cutting assembly comprising:

a hub attachable to a driving shaft for rotation in spaced relation with the die face;

a cutting element mounted on the hub for rotation therewith, said cutting element having a cutting edge for movement adjacent the downstream surface of die plate; and

a first surface on the cutting assembly corresponding to a second surface on the extrusion die plate such that an interface is established between the cutting assembly and the extrusion die which permits free rotation of the

cutting assembly and forms a barrier to prevent pellet migration between and said bottom surface of said recess in the center of said die ring the hub; wh rein the first surface can be a barrier element or alternatively the second surface can be a barrier element.

The problems and disadvantages of the prior art pelletizer, as described above, are avoided or at least minimized by using the pelletizing assembly of the present invention.

The invention also provides a process and a method for preventing material from agglomerating in a pelletizing assembly using the pelletizer described above.

Referring to FIGs. 3-14, the present invention further relates to the use of a shroud 33 (Fig. 3) or 103 (Fig. 13), fixedly mounted on either the circular hub or the surface of the recess in center of the die ring to prevent agglomeration in various agglomerate inviting sites in the pelletizer such as the gap 35 between the die face and the cutting hub, the sites where the cutting blades are mounted, areas around the cutting blades, the area between the inner surface of the cutting blades and the hub and shroud, etc.

The present invention will be described and illustrated by the following embodiments, which are provided for illustration purpose only and not intended to limit the scope of the instant invention.

Reference is first made to FIGs. 3-10 which illustrate an improved underwater pelletizer according to the first preferred embodiment of the 'present invention.

Referring to FIG. 3, the pelletizer comprises, in substance, a die plate 37 having a plurality of circumferentially spaced and radially disposed bores or recesses 39 which receive electrically operated heating cartridges for heating die plate in a well known manner. The die plate can also be steam heated via channels formed in the die. The adapter 39 and the die plate 37 include an

inlet passageway 41 for extrudable material such as therm plastic polymer which is diverted by a nose c ne 43 through a plurality f channels 44 s that the extrudable material is extruded in a c ntinu us ribbon or strand from the orifices 47 of the die face 45 which is the downstream side of the die plate. The die face 45 is provided with a wearable surface forming a circular die ring 49 projecting outwardly from the die face toward the hub, i.e. elevated or raised from the die face. Since the wearable surface on the die ring is elevated or projecting outwardly from the die face, it forms a recess or a bowl shaped cavity 35 which invites agglomeration of the pellets. The die ring 49 has a width which is substantially equal to that of the cutting edge of the cutting blades 57 thereby establishing an even wear of the cutting edge of the cutting blades and the die ring, as cutting blades 57 are wearing against the die ring 49 during the pelletizing operation. When the cutting edge of the cutting blades 57 are wider than the die ring, the cutting edge of the blades would not wear evenly. This can lead to a "crowning" of the inside and/or outside edges of the die and possible damage to the die plate body as the knives wear into softer material. When the cutting edge of the cutting blades are narrower than the die ring, there would be groove formation on the die ring over which a new cutting blade 57 may not track properly on the die ring.

Associated with the wearable surface, formed on the die ring 49, is a multi-bladed rotatable cutting assembly 51. Referring to FIGs. 7 and 8, the cutting assembly 51 includes cutting blade(s) 57 mounted on a circular hub 53 for rotation. The hub is attachable to a shaft 55 (see FIGs. 3-4) having a center axis of rotation and rotatable coaxially to the die face 45, so that the extruded ribbon or strand of material will be cut into a plurality of pellets. The sizes and dimensions of all the parts depend upon the size of the pelletizers. The number of cutting blades mounted on the cutting assembly also varies with the type and size of the pelletizer, non-

limiting range of the number f blades is from 1 to about 500.

As a specific aspect of the first preferred embodiment of the present invention, a protective ring element of shroud element 33 such as skirt-like annular ring or liner is snugly fitted to the outer periphery of the hub 53 (see FIG. 5 & FIG. 6). The shroud 33 has a slot 59 to permit the insertion of the cutting blades which are mounted on the hub 53 by any suitable means such as a bolt or screw 61 as shown in FIG. 9.

Referring to FIG. 5 and 6, the outer diameter of the shroud 33 is substantially equal to the inner diameter of the die ring 49 thereby allowing the cutting edges of the cutting blades 57 to be in close contact with the wear surface of the die ring 49. In pelletizing operations, the cutting blades rotate with the hub following the die ring as the track. Preferably, a minimal clearance exist between the shroud and the die ring to permit free rotation. The outer periphery of the shroud is held to a close tolerance to the inner diameter of the die ring to effect a barrier against pellet migration.

As non-limiting illustrative example, the outer diameter of the shroud is slightly smaller, e.g. from about 0.01mm to about 0.25 mm smaller, than the inner diameter of the die ring to allow a portion of the skirt 63 adjacent to the die ring to be inserted or protruded in to the bowl-like recess or cavity in the center of the die ring. In a non-limiting example of the hub design of the first specific embodiment of the present invention, the inner surface of the hub 67 is downstream from the cutting plane of the cutting blade and thereby forming a gap 65 between the inner surface of the hub 67 and cutting plane or downstream surface of the die ring 49 of the cutting blade. The shroud substantially covers the bowl-shaped recess or cavity 35 thereby preventing the pellets from entering the recess or cavity 35 and the space 65 under the hub.

In a prior art pelletizer, without the shroud, the pellets, especially high melt flow thermoplastic polymers having slow crystallizati n rate, tend t agglomerate within the gap or chamber between the inner surface of the hub 67 and the bottom surface 69 of the recess. The present shroud 33 forms a seal or barrier thereby effectively prevents the pellets from entering the gap between the inner surface of the hub 67 and the bottom 69 surface of the recess thereby substantially prevents pellet recirculation under the hub, thus eliminating agglomeration of the pellets in the gap and the inner surface 67 of the hub. The cutting blades are bolted on the inner side of the hub, thus there are no notches, slots or screw head for the polymer to hang on. Since the shroud also prevents pellets from entering the inner surface 67 of the hub, the shroud 33 thus prevents pellet agglomeration at the screw 61 and the area adjacent to the screw which would otherwise invite trapping and agglomeration of the polymer.

As a specific embodiment of the first preferred embodiment of the present invention, a portion of the shroud 71 at the upstream side facing the die protrudes into the recess formed by the die ring and being wearable against the bottom surface 69 of the recess when the cutting blades along with the hub are advanced toward the die to compensate for the reduction in the length of the blade caused by the wearing of the cutting blades. FIG. 5 shows an edge 71 of the shroud not in contact with bottom surface of the recess 69 of the die face when the cutting blades are relatively new. FIG. 6 illustrates the wearing of the edge of the shroud 71 against the bottom of the recess 69, when a cutting blade has been worn and the cutting hub has been advanced.

As another specific embodiment of the first preferred embodiment of the present invention, a portion of the shroud 71 at the upstream side facing the die is thinner than the remaining portion of the shroud thereby reducing

the amount of scrap material generated from the wear of the shr ud.

The shroud is made of any suitable material. Where the shroud is wearable, it is preferred that the shroud is made of a material compatible with the material for making the pellets. Non-limiting examples of such materials include polyethylene, polypropylene, Teflon, Nylon, phenolic resin, polyacrylic polymer, polyester, polycarbonate, etc.

The cutting blades 57 are mounted to the hub, preferably to the inner surface of the hub and rotate during a pelletizing operation in close contact with the downstream surface of the die ring 49. Since the pellets are prevented from contacting the inner surface by the shroud, mounting the cutting blades to inner surface 67 effectively prevents the agglomeration of the pellets around the bolts and screws 61.

Reference is now made to FIGS. 11-12 which show another form of pelletizer according to the second preferred embodiment of the present invention.

As there shown, the cutting assembly comprises a backplate or hub 73 of circular configuration having a cup-shaped shroud 75 fixedly mounted on the outer periphery and inner surface of the cutting hub. The cup-shaped shroud has a slot 77 at the outer periphery of said shroud to permit the insertion of the cutting blades 79. Spring(s) 81 are secured between the inner surface of the hub 83 facing the die and inner bottom side 85 of the cup-shaped shroud to keep the cup-shaped shroud in the desired position relative to the die plate when the hub along with the knives are advanced toward the die to compensate for wearing of the knives 79.

Similar to the shroud described in the first preferred embodiment of the present invention, the cup-shaped shroud element has an outer diameter substantially equal to the inner diameter of said die ring thereby allowing said cutting edge of the cutting element moving adjacent the downstream surface of the die ring, and an

interface is established between the shroud and the surface of the die ring which permits fr e rotation of th cutting assembly and forms a barrier to prev nt pellet migration between bottom surface f the cup-shap d shroud and the bottom surface of said recess on the die face.

The cutting blades are secured to the outer surface of the hub, and said slot on the outer periphery of the shroud for insertion of the cutting element has a size and a shape with sufficient clearance adapted to allow advancement of the hub and the cutting element affixed thereto to compensate for the wear of the cutting edge of the cutting blades. The shroud touches the bottom surface of the recess on the die face via a hard button 89 to minimize wear and friction.

There is a backcover 91 secured to the hub having the outer diameter substantially equal to the outer diameter of the hub to prevent thermoplastic material from agglomerating at the outer surface of the hub and at the sites where the cutting blades are affixed to the hub.

As a specific aspect of the second preferred embodiment, the backcover has an axial extension 85 adapted to cover the a hole in the slot located on the outer periphery of the shroud formed from the advancement of the hub, thereby reducing the areas where pellets can agglomerate. In this embodiment, as the cutting blades or knives wear from close contact with the die ring, the hub and the cutting blades are advanced toward the die with the springs(s) 81 being pressed to a shorted length. As shown in FIG. 12, the relative position of the shroud to the die remains unchanged as the hub is advanced. An O-ring 87 located between the inside of the cup-shaped shroud and the outer periphery of the hub serves to provide sufficient friction to cause the shroud 75 to rotate with the hub 73 driven by the shaft during pelletizing operation, as well as center of the shroud with respect to the hub.

Suitable material for the non-wearing type of shroud can also be made of the polymers described above or

metal, such as stainless steel, aluminum, brass, bronze, etc.

Reference is now made t FIGs. 13-14 which illustrate an improved underwater pell tizer acc rding to the third preferred embodiment of the present invention.

As a specific aspect of the third preferred embodiment of the present invention, a protective cup-shaped shroud element 103 is fixedly mounted on the surface of the recess or bowl-shaped cavity in the center of the die ring to prevent agglomeration in various agglomerate inviting sites in the pelletizer. The outer diameter of the shroud 103 is substantially equal to the inner diameter of the die ring 49. The downstream edge 34 of the shroud facing the hub is held to a minimum clearance with the inner face of the hub. The outer periphery 36 of the shroud is held to a minimum clearance to the inner surface of the cutting blades. These special features of the shroud effect a barrier against pellet migration between the die face and the hub, and also permit free rotation of hub. In pelletizing operations, the cutting blades rotate with the hub following the die ring as the track and allowing the cutting edges of the cutting blades 57 to be in close contact with the wear surface of the die ring 49.

In a non-limiting example of the hub design of the third specific embodiment of the present invention, the inner surface of the hub 109 is downstream from the cutting plane of the cutting blade and thereby forming a gap 35 between the inner surface of the hub 109 and the bottom surface 111 of the recess. The shroud substantially covers the bottom surface 111 and side surface 112 of the bowl-shaped recess or cavity 35 thereby preventing the pellets from entering the recess or cavity 35 and the space under the hub.

In a prior art pelletizer, without the shroud, the pellets, especially high melt flow thermoplastic polymers having slow crystallization rate, tend to agglomerate within the gap or chamber between the inner surface of the hub and

the bottom surface of th recess. The pres nt shr ud 103 forms a seal or barrier thereby effectively prevents the pellets fr m ent ring the gap b tween the inner surface of the hub 109 and the bottom 111 surface of the recess thereby substantially prevents pellet recirculation under the hub, thus eliminating agglomeration of the pellets in the gap and the inner surface 109 of the hub. The cutting blades are bolted on the outer (downstream) side of the hub which is preferably covered by a back cover, thus there are no notches, slots or screw heads for the polymer to hang on.

As a specific embodiment of the third preferred embodiment of the present invention, at least a portion of the shroud at the side facing the hub being wearable against the inner surface of the hub as the cutting assembly is advanced toward the die to compensate for the wearing of the cutting blades. Optionally at least a portion of the shroud 34 at the side facing the hub being thinner than the remaining portion of the shroud thereby reducing the amount of scrap material generated from the wear of the shroud; and optionally a portion of the hub at the inner side facing the die has a portion with a smaller diameter thereby creating a recess or a shoulder 63, said shoulder 63 is designed to be sealingly interfacing with the shroud 103 to prevent pellet migration into the space 35.

The cutting blades 57 are mounted to the hub, preferably to the outer/downstream side of the hub and rotate during a pelletizing operation in close contact with the downstream surface of the die ring 49. Optionally, there is a back cover 105 fixedly attached to the hub thereby effectively preventing the agglomeration of the pellets around the mounting bolts or screws 106. Optionally, the hub at the downstream side, facing the die, is recessed at the outer periphery to accommodate the mounting bolts 66 for holding the cutting blades 57; and the back cover 105 optionally has an extension 68 which extends into the recess 107 which accommodates the cutting blades 57 so as to

prevent pellet migration and agglomeration in the recess 107 and around the mounting bolts or scr ws 106.

In a fourth embodiment of the present invention, a shroud element 103 is in a form of a skirt-like annular ring or liner fixedly mounted to the inner surface of the die ring, i.e. the surface the bowl-shaped cavity/recess, especially the side surface 112 of the cavity/recess.

Similar to the shroud described in the third embodiment of the present invention, the skirt-shaped shroud element has an outer diameter substantially equal to the inner diameter of said die ring. The downstream edge 34 of the shroud facing the hub is held to a minimum clearance with the inner face of the hub. The outer periphery 36 of the shroud is held to a close tolerance to the inner surface of the cutting blades. These special features of the shroud effect a barrier against pellet migration between the die face and the hub, and also permit free rotation of hub. Other features are similar to that described in the first embodiment of the present invention.

In each of the foregoing embodiments, the cutting blades 57 engage the surface of the die ring at an angle selected from about 10° to about 60°, preferably from about 20° to about 40°, and still more preferably from about 30° to about 36°. A low incident angle not only enables a clean cut, instead of smearing, of the extrudate but also minimizes turbulence in the surrounding cooling water. Turbulence in the cooling water is undesirable because it results in sharp changes in flow directions which tends to both distort still molten pellets and can lead to pellet recirculation and agglomeration in stagnant areas. The low incidence angle used in the present cutting assembly also reduces or eliminates the cavitation zone that forms in the zone behind the cutting blades. Other prior art blunt designs with higher incidence angles may lead to the formation of a vapor pocket on the trailing edge of the knives. This vapor pocket rotates with the blades and acts as an insulating medium between the surrounding cooling

water and the face of the die ring. As a consequence the die face runs hotter than if cooling waster was in contact with the die, thereby increasing the likelihood of smearing of the extruded material and producing n n-discrete pellets.

The cutting blades of the present invention have cutting edges parallel to plane of rotation of the hub. The width of the cutting edge of the cutting blade is substantially equal to that of the die ring, and the cutting blades have inner edges contoured to conform in its angular position to curvature of the outer periphery of the shroud and are in continuous contact with, or has minimal clearance with, the outer periphery of said shroud thereby substantially eliminating gap between inner surface of cutting blade and the outer periphery of the shroud. The outside edges of the cutting blades are contoured in the same curvature as the inner edges so that the width of the cutting edges remain constant as the cutting blades wear.

As an illustrative example, in operation, hot thermoplastic material is continuously extruded through the orifices of the die ring in the form of hot thermoplastic rods or strands and are cut into short lengths or pellets by the knives operatively in contact with the die ring. The pelletizer is immersed in water. The pellets are quickly cooled by the water and carried in suspension from the housing to a collection station.

The fifth preferred embodiment of the present invention relates to a process or a method for preventing material from agglomerating in an pelletizing assembly using the pelletizing assemblies described above.

In an prophetic illustrative example, an ultra low melt viscosity thermoplastic polymer having a melt viscosity of 300,000 or lower measure by Brookfield Viscometer using ASTM D2556 at 350°F, and a melt index of about 100 dg/min or higher measured by ASTM 1238 condition E at 190°C and 2.16 kg wt. is extruded using a pelletizer according to the present invention. Specifically, a polymeric feedstock comprising an ultra low melt viscosity

thermoplastic butene-1-ethylene cop lymer consisting essentially of (i) from ab ut 92 wt % to about 98 wt% of butene-1 and (ii) from about 2 wt% to about 8 wt% f ethylene is extruded using a pelletizer f the present invention. The underwater pelletizer will produce ultra low viscosity polymer pellets without shut-down of the extrusion/pelletization line due to plug-up of the pelletizer for an extensive period of time. This will compare favorable over the prior art pelletizer described in the Background of Invention.

In each of the foregoing embodiments, the number of blades of the rotary cutter member should by no means be limited to the illustrated examples and may be any other number which is more than one.

The ranges and limitations provided in the instant specification and claims are those which are believed to particularly point out a distinctly claim the instant invention. It is, however, understood that other ranges and limitations that perform substantially the same function in substantially the same manner to obtain the same or substantially the same result are intended to be within the scope of the instant invention as defined by the instant specification and claims.

CLAIMS

1. A pelletizing ass mbly for pelletizing an extruded material, said pelletizing assembly comprising:

an extrusion die plate c mprising:

a die face at a downstream side of the die plate;

a die ring formed on the downstream side of the die face having a wear surface projecting outwardly from the die surface to form a recess in the center of the die ring, and said recess having a bottom surface at the downstream side of said recess; and

a channel means extending from upstream side of the die plate to the die face adapted to deliver the extruded material from the upstream side of the die plate to the die face for extrusion, and said channel means forming an orifice in the die face for extruded material to exit the die plate;

a cutting assembly mounted for rotation adjacent the die face, said cutting assembly comprising:

a hub attachable to a driving shaft for rotation in spaced relation with the die face;

a cutting element mounted on the hub for rotation therewith, said cutting element having a cutting edge for movement adjacent the downstream surface of die plate; and

a first surface on the cutting assembly corresponding to a second surface on the extrusion die plate such that an interface is established between the cutting assembly and the extrusion die which permits free rotation of the cutting assembly and forms a barrier to prevent pellet migration between the hub and said bottom surface of said recess in the center of said die ring.

2. A pelletizing assembly according to claim 1, wherein said cutting assembly comprises a shroud element,

said first surface is located at the upstream side of said shroud element and faces th rec ss in th center of the die ring, said shroud element has an outer diameter substantially qual to the inner diameter of said die ring thereby allowing said cutting edge of the cutting element moving adjacent the downstream surface of the die ring, and an interface is established between said first surface on said shroud element and the second surface of the die plate which permits free rotation of the cutting assembly and forms a barrier to prevent pellet migration between inner surface of the hub and the bottom surface of said recess in the center of the die ring.

3. A pelletizing assembly according to claim 2, wherein the hub is a circular plate having a center axis of rotation and rotatable coaxially to the face of the die, said hub having an inner surface facing the die face, an outer surface adjacent the shaft, and an outer periphery,

said shroud element is fixedly mounted on outer periphery of the hub, and said shroud element having a slot to permit the insertion of the cutting element which is affixed to the inner surface of the hub facing the die, said cutting blade engages the surface of the die ring at an angle selected from about 10° to about 60°,

said cutting blade has a cutting edge parallel to plane of rotation of the hub, the width of the cutting edge of the cutting blade is substantially equal to that of said die ring,

said cutting element is a cutting blade having an inner edge contoured to conform in its angular position to curvature of the outer periphery of the shroud and has minimal clearance with the outer periphery of said shroud thereby substantially eliminating gap between inner surface of cutting blade and the outer periphery of the shroud, and

said cutting element has an outside edge contoured substantially concentric to the inner edge so that the width of the cutting edge remains constant as the cutting element wears.

4. A pelletizing assembly acc rding to claim 3, wherein a p rtion of the shr ud at the side facing the die protrudes into the recess formed by the die ring, and said portion of the shroud protruded int the recess is wearable against the bottom surface of the recess as the cutting assembly is advanced toward the die to compensate for the wearing of the cutting element.

5. A pelletizing assembly according to claim 2, wherein the hub is a circular plate having a center axis of rotation and rotatable coaxially in spaced relation to the face of the die, said hub having an inner surface facing the die face, an outer surface adjacent the shaft, and an outer periphery,

said shroud element is a cup-shaped shroud fixedly mounted on the outer periphery and inner surface of said cutting hub, said cup-shaped shroud having a slot at the outer periphery of said shroud to permit the insertion of the cutting element;

a spring is secured between the inner surface of the hub facing the die and inner bottom side of the cup-shaped shroud to maintain the desired position of the shroud relative to the die plate; and

an interface is established between the cup-shaped shroud element and the surface of the die ring which permits free rotation of the cutting assembly and forms a barrier to prevent pellet migration between bottom surface of the cup-shaped shroud and the bottom surface of said recess on the die face.

6. A pelletizing assembly according to claim 1, wherein said pelletizing assembly comprises a shroud element fixedly mounted to the surface of said recess in the center of the die ring, said shroud element has an outer diameter substantially equal to the inner diameter of said die ring, said second surface is the downstream edge of said shroud element, and an interface is established between the downstream edge of the shroud element and the inner surface of the hub which permits free rotation of the cutting

assembly and f rms a barrier t pr vent pellet migration between inner surface of the hub and the bottom surface of said recess on the di face.

7. A pelletizing assembly as described in claims 6, wherein the hub is a circular plate having a center axis of rotation and rotatable coaxially to the face of the die, said hub having an inner surface facing the die face, an outer surface adjacent the shaft, and an outer periphery; wherein the outer periphery of the shroud element is held to a minimum clearance to the inner surface of the cutting blades;

wherein said cutting blade engages the surface of the die ring at an angle selected from about 10½ to about 60½;

wherein said cutting blade has a cutting edge parallel to plane of rotation of the hub, the width of the cutting edge of the cutting blade is substantially equal to that of said die ring,

wherein said cutting blade has an inner edge contoured to conform in its angular position to curvature of the outer periphery of the shroud and has minimal clearance with the outer periphery of said shroud thereby substantially eliminating the gap between inner surface of cutting blade and the outer periphery of the shroud, and

wherein said cutting blade has an outside edge contoured substantially concentric to the inner edge so that the width of the cutting edge remains constant as the cutting element wears.

8. A pelletizing assembly according to claim 7, wherein a portion of the shroud facing said hub is wearable against the inner surface of the hub as the cutting assembly is advanced toward the die to compensate for the wearing of the cutting element; wherein a portion of the shroud element at the side facing the hub is thinner in width than the remaining portion of the shroud thereby reducing the amount of scrap material generated from wearing of the shroud.

9. A pell tizing assembly according to claim 6, wherein said shroud element is a cup-shaped element covering both th bottom surface and side surface of said recess, or a skirt shaped element m unted t the side surface of the recess.

10. A process for pelletizing a molten thermoplastic material in a liquid medium using a pelletizing assembly according to any of the preceding claims.

FIG.1
(PRIOR ART)

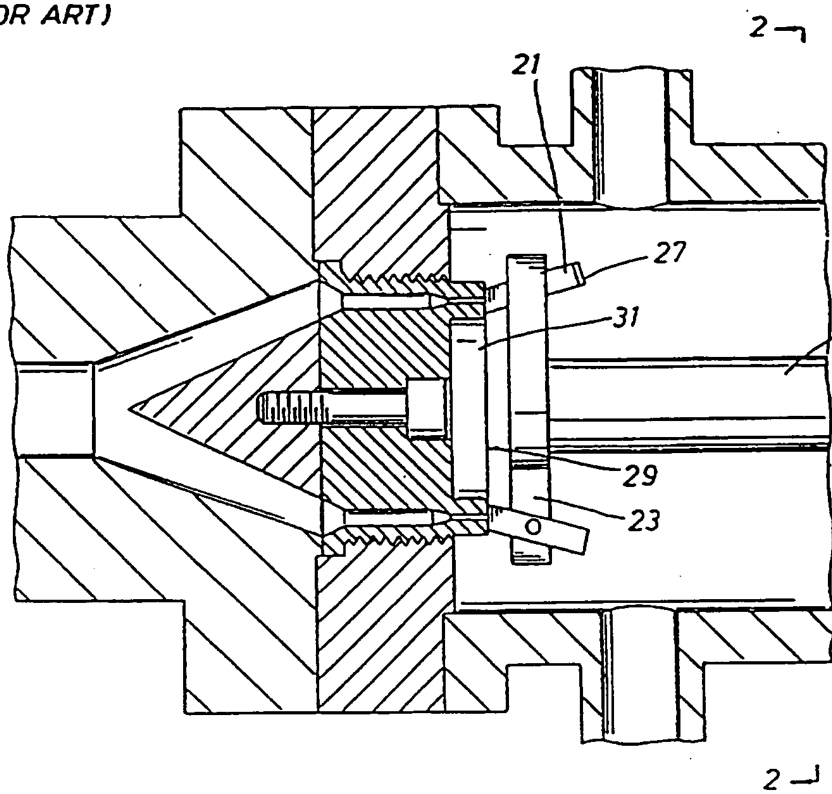


FIG. 2
(PRIOR ART)

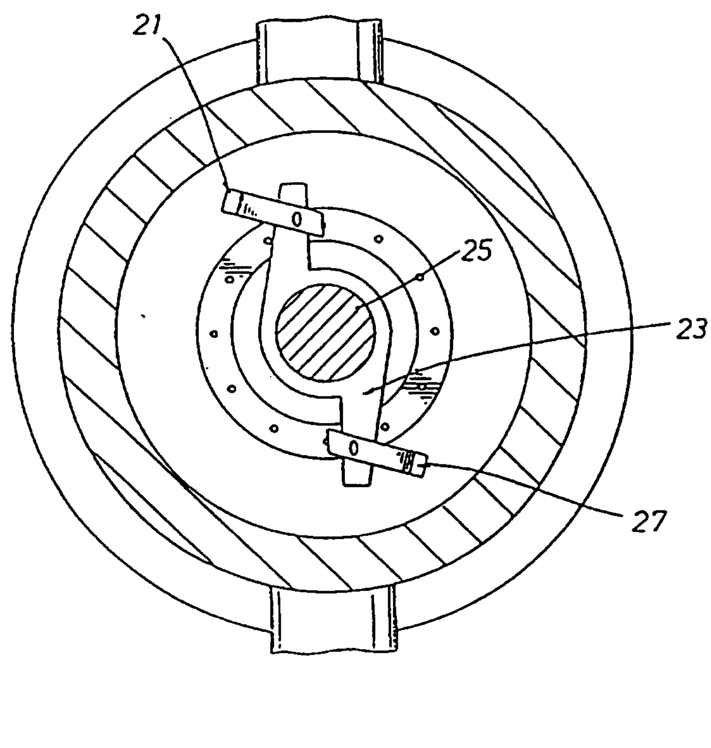
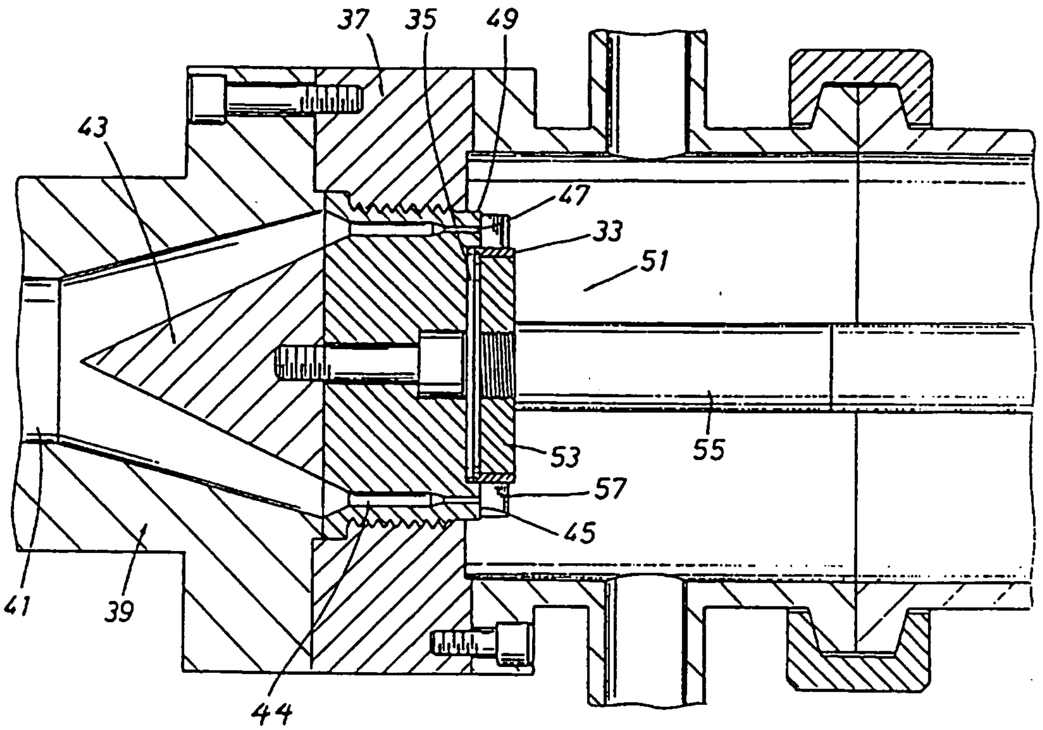


FIG. 3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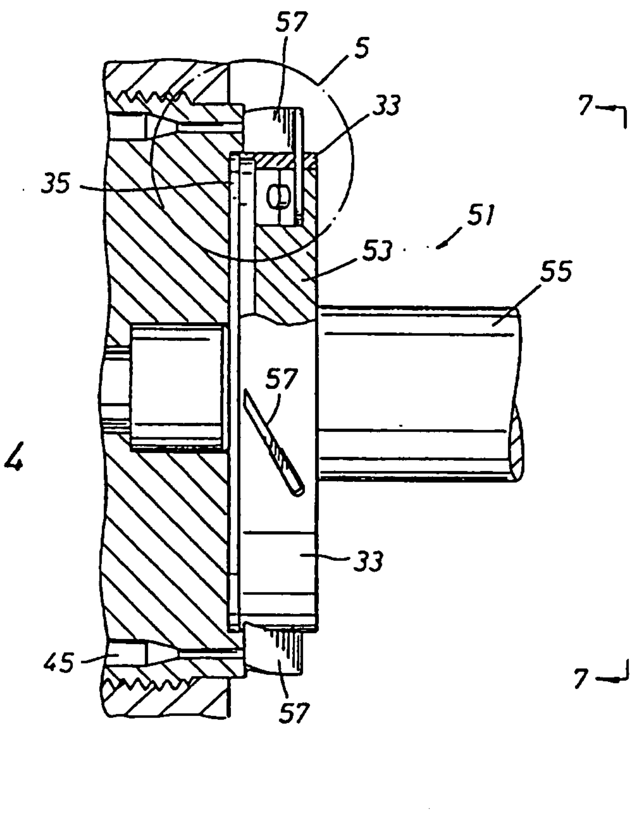
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FIG. 4

FIG. 5

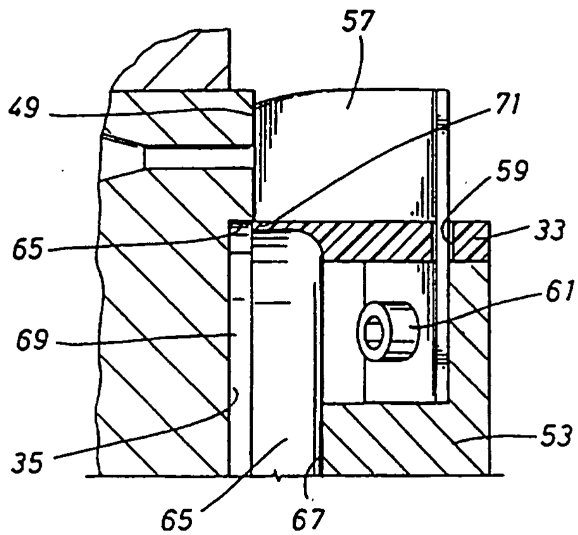


FIG. 6

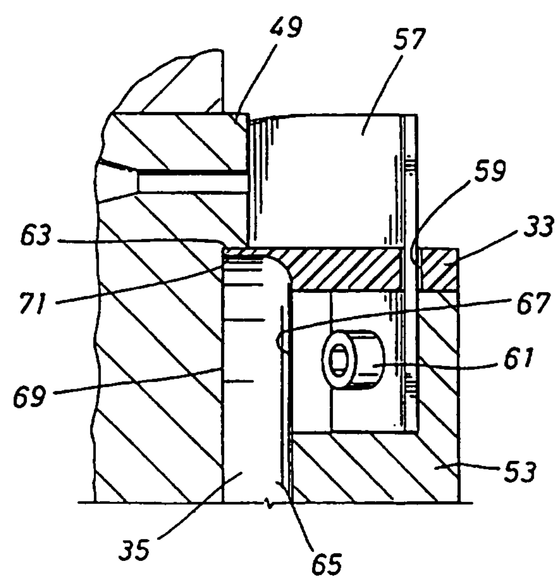


FIG. 7

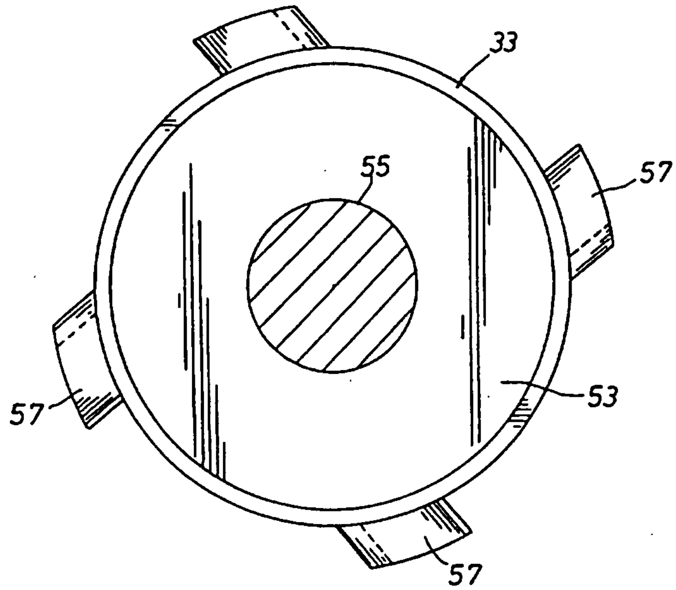


FIG. 8

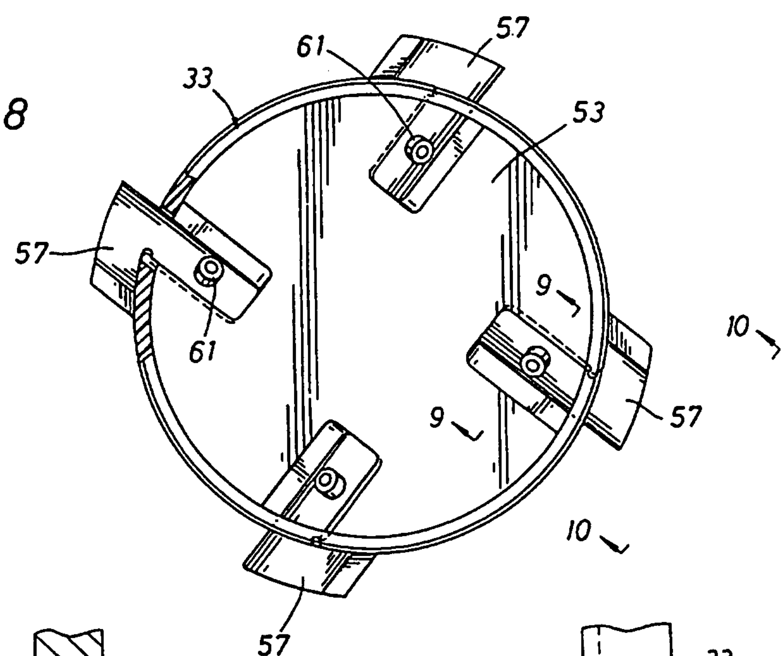
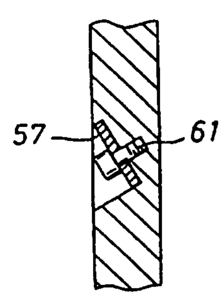


FIG. 9



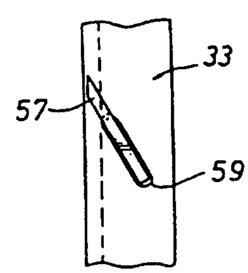


FIG. 10

FIG. 11

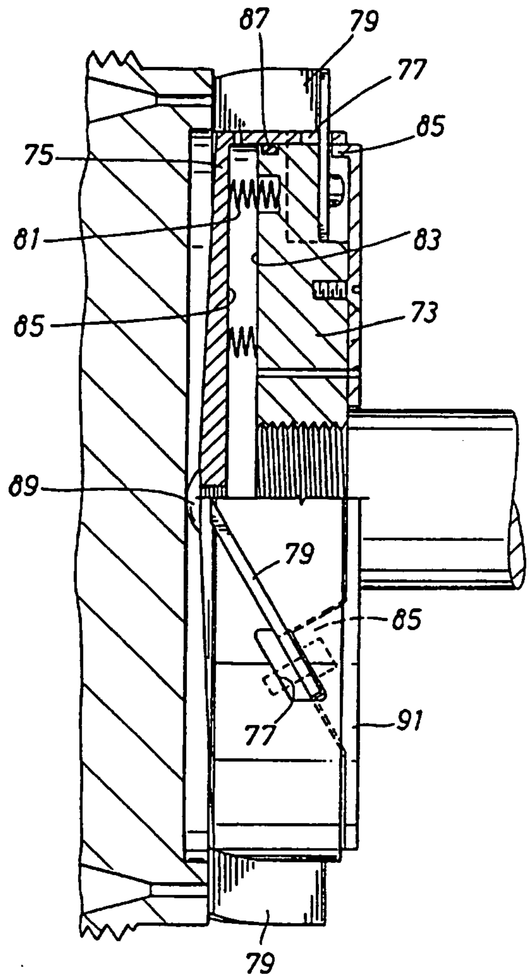


FIG. 12

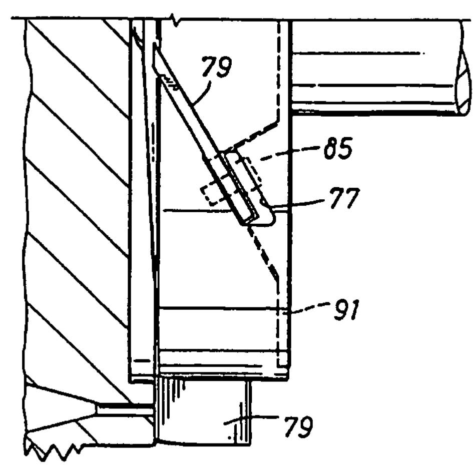


FIG. 13

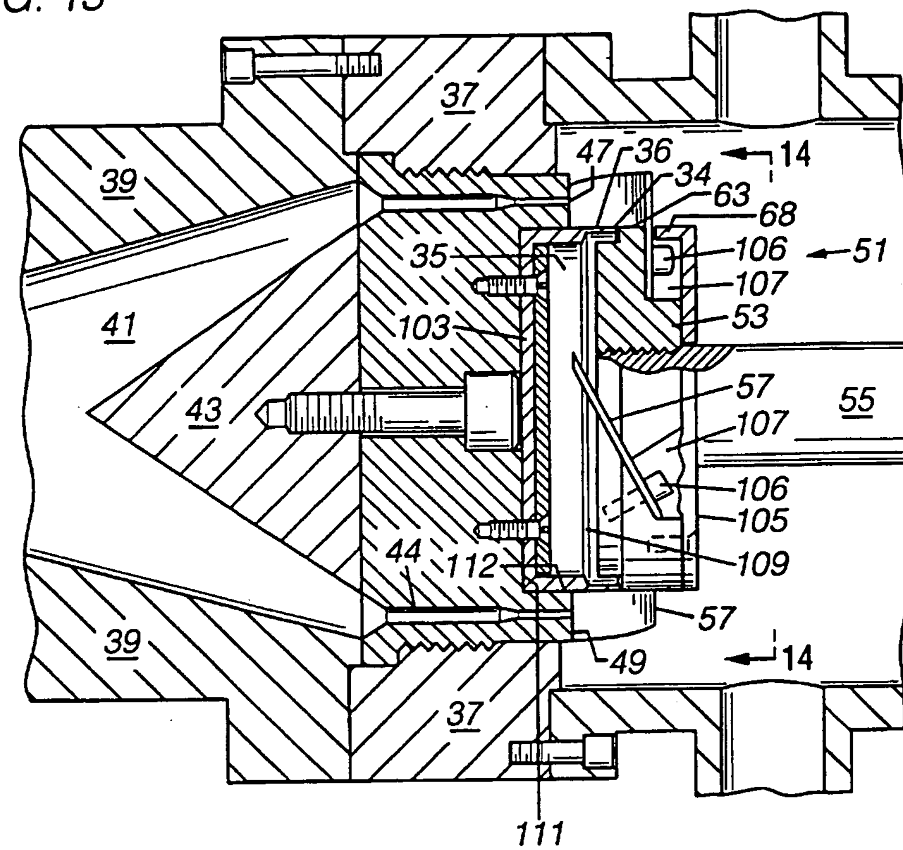

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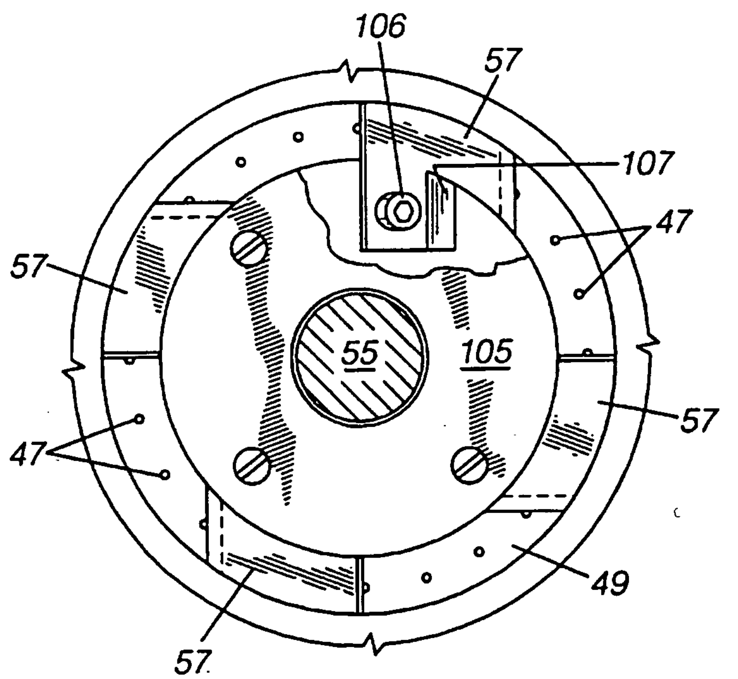
FIG. 14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INTERNATIONAL SEARCH REPORT

Intern. .l Application No
PCT/US 96/05822

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B29B9/06 B26D7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B29B B01J B26D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. D CUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US,A,4 321 026 (FRIEDRICH LAMBERTUS) 23 March 1982 see the whole document see very specially figure 3 see column 1, line 46 - line 57 see column 2, line 12 - line 19 see column 2, line 54 - line 57 see column 3, line 54 - column 4, line 52 see claim 1 ---	1,2,6,9,10 3,7

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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Date of the actual completion of the international search	Date of mailing of the international search report
22 July 1996	31.07.96

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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Molto Pinol, F

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INTERNATIONAL SEARCH REPORT

Intern. :l Application No
PCT/US 96/05822

C.(Continuation) D CUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	GB,A,1 220 399 (BAKER PERKINS) 27 January 1971 see the whole document see figure 1 see page 1, left-hand column, line 11 - right-hand column, line 61 see page 2, right-hand column, line 96 - page 3, left-hand column, line 50 see very specially page 2, right-hand column, line 112 - page 3, left-hand column, line 11 (see very specially (scope-related) description of detail 44) see claims 3-5,8 ---	1-3,6,7, 10 5
X	US,A,3 673 298 (RICHARD W. MILER) 27 June 1972 see the whole document see figure 1 see column 1, line 21 - line 25 see column 2, line 33 - line 75 see specially column 2, lines 44-75 (see very specially, (scope-related) description of detail 50) see claims 3,6 ---	1-3,6,7, 10
A	US,A,4 099 900 (CHRISTOPHER G. BRADBURY ET AL.) 11 July 1978 see the whole document ---	1,7,10
A	GB,A,2 124 964 (KENSAKU NAKAMURA) 29 February 1984 see the whole document ---	1-3,6,7, 10
A	US,A,3 324 510 (RUDOLF KLEEB) 13 June 1967 see figure 3 ---	1,2,9,10
A	US,A,4 621 996 (RAYMOND E. HUNDLEY III) 11 November 1986 cited in the application see the whole document -----	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern   al Application No
PCT/US 96/05822

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-4321026	23-03-82	DE-A-	2814113	04-10-79
		FR-A-	2421041	26-10-79
		GB-A,B	2017571	10-10-79
		JP-C-	1014778	29-09-80
		JP-A-	54135852	22-10-79
		JP-B-	55006043	13-02-80
		SE-A-	7902581	02-10-79
GB-A-1220399	27-01-71	CH-A-	512258	15-09-71
		DE-A-	1813221	16-10-69
		FR-A-	1599897	20-07-70
		GB-A-	1220400	27-01-71
		NL-A-	6817572	10-06-69
		US-A-	3564650	23-02-71
US-A-3673298	27-06-72	NONE		
US-A-4099900	11-07-78	US-A-	4151241	24-04-79
GB-A-2124964	29-02-84	NONE		
US-A-3324510	13-06-67	NONE		
US-A-4621996	11-11-86	NONE		